费曼3作业1

郑子诺,物理41

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70.6:

(a):Because $L \gg d, L \gg a$,we have:

$$d\,\theta \approx m\lambda$$

$$L\theta \approx x$$

and we have de-Broglie formula:

$$\lambda = \frac{h}{p_0}$$

therefore:

$$a = \frac{L}{d}\frac{h}{p_0}$$

(b):We add the altered phase to the first equation above:

$$d\theta - \delta\phi_1 + \delta\phi_2 \approx m\lambda$$

and the fact that the central maximum appears when $m = 0$.Then we have:

$$S = +(\delta\phi_1 - \delta\phi_2)\frac{L}{d}\frac{h}{p_0}$$

(c):Because the potential changed slightly on the vertical direction,we can make Taylor expansion and reserve the first-order:

$$\frac{p^2(x)}{2m} = \frac{p^2(0)}{2m} + V(0) - V(x)$$

$$p(x) = \sqrt{p^2(0) + 2m(V(0) - V(x))} \approx p(0) + \frac{m}{p(0)}(V(0) - V(x))$$

and if V(x) varies slowly,we have:

$$F = -\frac{\partial V}{\partial x} \approx -\frac{V(x) - V(0)}{x}$$

$$p(x) = p(0) + \frac{Fx}{v}$$

(d):

(1):For the same reason above(L is very large),we can simply write:

$$\delta\phi_1 - \delta\phi_2 \approx (k_{up} - k_{down})L$$

and according to the de-Broglie formula:

$$p = \hbar k$$

use the result of (c) and let $x = \frac{d}{2}$we have:

$$\delta\phi_1 - \delta\phi_2 = \frac{d}{2v}\frac{F}{\hbar}L$$

(2):Use the result of (b) we have:

$$S = \frac{1}{2}F(\frac{L}{v})^2 = \frac{1}{2}Ft^2$$

It's not a surprise that the classical consequence related to the central maximum of the probability amplitude,which is just corresponded to the classical limitation(the most possible situation when $\hbar \to 0$).

70.7:

(a):The amplitude of "unflipped" path:

$$\langle x|S\rangle_1 = \alpha(\langle x|1\rangle\langle 1|S\rangle + \langle x|2\rangle\langle 2|S\rangle)$$

The amplitude of "flipped" path:

$$\langle x|S\rangle_2 = \beta(\langle x|1\rangle\langle 1|S\rangle + \langle x|2\rangle\langle 2|S\rangle)$$

Therefore the distribution P is:

$$P = (|\alpha|^2 + |\beta|^2)|\langle x|1\rangle\langle 1|S\rangle + \langle x|2\rangle\langle 2|S\rangle|^2$$

(b):Obviously,the answer is the same as (a):

$$P = (|\alpha|^2 + |\beta|^2)|\langle x|1\rangle\langle 1|S\rangle + \langle x|2\rangle\langle 2|S\rangle|^2$$

(c):For every electron,no matter what spin it has,the distribution is the same,so the answer is the same:

$$P = (|\alpha|^2 + |\beta|^2)| \langle x|1\rangle \langle 1|S\rangle + \langle x|2\rangle \langle 2|S\rangle |^2$$

70.9:

(a):It's important that the photons are identical,so that the amplitude of p_{12} should contain two case:

$$\langle ab|\psi_{12}\rangle = \langle a|A\rangle \langle b|B\rangle + \langle b|A\rangle \langle a|B\rangle$$

and use symmetry:

$$\langle ab|\psi_{12}\rangle = c^2(\exp(2i\alpha_1) + \exp(2i\alpha_2))$$

then we have:

$$p_{12} = | \langle ab|\psi_{12}\rangle |^2 = |c|^4(2 + 2\cos 2k(R_2 - R_1))$$

(b):Let $\theta = \dfrac{D}{2R}$,we have:

$$d\,\theta \approx R_2 - R_1$$

$$p_{12} \propto 2 + 2\cos\frac{kD}{R}d$$

Hence we can measure how p_{12} changed when d varies,which is just like the distribution of interference.If we have measured the interval Δd between two maximum,then we have:

$$D = \frac{R}{\Delta d}\lambda \qquad \text{where } \lambda \text{ is the wavelength of the light}$$